

CLAIMS

(1) An electronic device, characterized by comprising:
three or more electrodes; and

a transporting layer constituted by a carbon nanotube structure formed into a network structure by a plurality of carbon nanotubes and cross-linked sites each constituted by chemical bonding of the different carbon nanotubes, in which a carrier is transported in accordance with a voltage applied to the electrodes.

(2) An electronic device according to claim 1, characterized in that the electrodes comprise at least a source electrode, a drain electrode, and a gate electrode to constitute a field effect transistor structure.

(3) An electronic device according to claim 2, characterized in that the field effect transistor structure comprises a MOS-FET structure.

(4) An electronic device according to claim 2, characterized in that the field effect transistor structure comprises a MES-FET structure.

(5) An electronic device according to any one of claims 1 to

4, characterized in that, in the carbon nanotube structure layer, the carbon nanotubes for connection between cross-linked sites of the carbon nanotubes comprise mainly single-wall carbon nanotubes.

(6) An electronic device according to any one of claims 1 to 4, characterized in that, in the carbon nanotube structure layer, the carbon nanotubes for connection between cross-linked sites of the carbon nanotubes comprise mainly multi-wall carbon nanotubes.

(7) An electronic device according to any one of claims 1 to 6, characterized in that chemical bonds constituting the cross-linked sites comprise at least one chemical bond selected from the group consisting of $(-\text{COO}(\text{CH}_2)_2\text{OCO}-)$, $-\text{COOCH}_2\text{CHOHCH}_2\text{OCO}-$, $-\text{COOCH}_2\text{CH}(\text{OCO}-)\text{CH}_2\text{OH}$, $-\text{COOCH}_2\text{CH}(\text{OCO}-)\text{CH}_2\text{OCO}-$, and $-\text{COO}-\text{C}_6\text{H}_4-\text{COO}-$.

(8) An electronic device according to any one of claims 1 to 7, characterized in that the chemical bonds constituting the cross-linked sites comprise at least one chemical bond selected from the group consisting of $-\text{COOCO}-$, $-\text{O}-$, $-\text{NHCO}-$, $-\text{COO}-$, $-\text{NCH}-$, $-\text{NH}-$, $-\text{S}-$, $-\text{O}-$, $-\text{NHCOO}-$, and $-\text{S-S}-$.

(9) An electronic device according to claim 1, characterized in that the carbon nanotube structure is obtained by using a solution containing a plurality of carbon nanotubes to which functional groups

are bonded and forming a cross-linked site through chemical bonding of the functional groups bonded to the carbon nanotubes.

(10) An electronic device according to claim 9, characterized in that the carbon nanotube structure is obtained by curing a solution containing carbon nanotubes having functional groups and a cross-linking agent that prompts a cross-linking reaction with the functional groups, prompting a cross-linking reaction between each of the functional groups bonded to the different carbon nanotubes and the cross-linking agent, and forming a cross-linked site.

(11) An electronic device according to claim 10, characterized in that the cross-linking agent comprises a non-self-polymerizable cross-linking agent.

(12) An electronic device according to claim 10 or 11, characterized in that the functional groups comprise at least one group selected from the group consisting of -OH, -COOH, -COOR (where R represents a substituted or unsubstituted hydrocarbon group), -COX (where X represents a halogen atom), -NH₂, and -NCO, and the cross-linking agent comprises a cross-linking agent which may prompt a cross-linking reaction with the selected functional groups.

(13) An electronic device according to any one of claims 10

to 12, characterized in that the cross-linking agent comprises at least one cross-linking agent selected from the group consisting of a polyol, a polyamine, a polycarboxylic acid, a polycarboxylate, a polycarboxylic acid halide, a polycarbodiimide, a polyisocyanate, and hydroquinone, and the functional groups comprise functional groups which may prompt a cross-linking reaction with the selected cross-linking agent.

(14) An electronic device according to claim 10 or 11, characterized in that:

the functional groups comprise at least one group selected from the group consisting of $-OH$, $-COOH$, $-COOR$ (where R represents a substituted or unsubstituted hydrocarbon group), $-COX$ (where X represents a halogen atom), $-NH_2$, and $-NCO$;

the cross-linking agent comprises at least one cross-linking agent selected from the group consisting of a polyol, a polyamine, a polycarboxylic acid, a polycarboxylate, a polycarboxylic acid halide, a polycarbodiimide, a polyisocyanate, and hydroquinone; and

the functional groups and the cross-linking agent are respectively selected in such a manner that combination of the functional groups and the cross-linking agent may prompt a cross-linking reaction with each other.

(15) An electronic device according to claim 9, characterized in that the cross-linked sites are constituted by chemical bonding of the functional groups.

(16) An electronic device according to claim 15, characterized in that reactions for causing the chemical bonding comprise at least one selected from the group consisting of dehydration condensation, a substitution reaction, an addition reaction, and an oxidation reaction.

(17) An electronic device according to any one of claims 1 to 16, characterized in that the transporting layer is obtained by patterning the carbon nanotube structure into a shape corresponding to a formation area of the transporting layer.

(18) An electronic device according to any one of claims 1 to 17, characterized by comprising a flexible substrate on which the electrode and the transporting layer are formed.

(19) An integrated circuit, characterized by comprising: a substrate; and a plurality of electronic devices each of which is described in any one of claims 1 to 17, the electrodes being integrated on the substrate.

(20) A method of manufacturing an electronic device that includes, on a base body, three or more electrodes and a transporting layer in which a carrier is transported in accordance with a voltage applied to the electrodes, characterized by comprising:

a supplying step of supplying the base body with a solution containing a plurality of carbon nanotubes to which functional groups are bonded; and

a cross-linking step of chemically bonding the functional groups, constructing a network structure in which the carbon nanotubes mutually cross-link, and forming a carbon nanotube structure used as the transporting layer.

(21) A method of manufacturing an electronic device according to claim 20, characterized in that the supplying step comprises an applying step of applying the solution onto the base body, and the carbon nanotube structure is of a film shape.

(22) A method of manufacturing an electronic device according to claim 20 or 21, characterized in that the carbon nanotubes comprise mainly single-wall carbon nanotubes.

(23) A method of manufacturing an electronic device according to claim 20 or 21, characterized in that the carbon nanotubes comprise mainly multi-wall carbon nanotubes.

(24) A method of manufacturing an electronic device according to any one of claims 20 to 23, characterized in that the solution contains a cross-linking agent for cross-linking the functional groups.

(25) A method of manufacturing an electronic device according to claim 24, characterized in that the cross-linking agent comprises a non-self-polymerizable cross-linking agent.

(26) A method of manufacturing an electronic device according to claim 24 or 25, characterized in that the functional groups comprise at least one group selected from the group consisting of -OH, -COOH, -COOR (where R represents a substituted or unsubstituted hydrocarbon group), -COX (where X represents a halogen atom), -NH₂, and -NCO, and the cross-linking agent comprises a cross-linking agent which may prompt a cross-linking reaction with the selected functional groups.

(27) A method of manufacturing an electronic device according to claim 24 or 25, characterized in that the cross-linking agent comprises at least one cross-linking agent selected from the group consisting of a polyol, a polyamine, a polycarboxylic acid, a polycarboxylate, a polycarboxylic acid halide, a polycarbodiimide,

a polyisocyanate, and hydroquinone, and the functional groups comprise functional groups which may prompt a cross-linking reaction with the selected cross-linking agent.

(28) A method of manufacturing an electronic device according to claim 24 or 25, characterized in that:

the functional groups comprise at least one group selected from the group consisting of -OH, -COOH, -COOR (where R represents a substituted or unsubstituted hydrocarbon group), -COX (where X represents a halogen atom), -NH₂, and -NCO;

the cross-linking agent comprises at least one cross-linking agent selected from the group consisting of a polyol, a polyamine, a polycarboxylic acid, a polycarboxylate, a polycarboxylic acid halide, a polycarbodiimide, a polyisocyanate, and hydroquinone; and

the functional groups and the cross-linking agent are respectively selected in such a manner that combination of the functional groups and the cross-linking agent may prompt a cross-linking reaction with each other.

(29) A method of manufacturing an electronic device according to claim 24 or 25, characterized in that the functional groups are comprise -COOR (where R represents a substituted or unsubstituted hydrocarbon group).

(30) A method of manufacturing an electronic device according to claim 29, characterized in that the cross-linking agent comprises a polyol.

(31) A method of manufacturing an electronic device according to claim 30, characterized in that the cross-linking agent comprises glycerin and/or ethylene glycol.

(32) A method of manufacturing an electronic device according to claim 20, characterized in that a reaction for causing the chemical bonding comprises a reaction for chemically bonding the functional groups.

(33) A method of manufacturing an electronic device according to claim 32, characterized in that the solution contains an additive for causing the chemical bonding of the functional groups.

(34) A method of manufacturing an electronic device according to claim 33, characterized in that the reaction comprises dehydration condensation and the additive comprises a condensation agent.

(35) A method of manufacturing a carbon nanotube structure according to claim 34, characterized in that the functional groups

comprise at least one selected from -COOR (where R represents a substituted or unsubstituted hydrocarbon group), -COOH, -COX (where X represents a halogen atom), -OH, -CHO, and -NH₂.

(36) A method of manufacturing an electronic device according to claim 35, characterized in that the functional groups comprise -COOH.

(37) A method of manufacturing an electronic device according to claim 34, characterized in that the condensation agent comprises at least one compound selected from the group consisting of sulfuric acid, N-ethyl-N'-(3-dimethylaminopropyl)carbodiimide, and dicyclohexyl carbodiimide.

(38) A method of manufacturing an electronic device according to claim 33, characterized in that the reaction comprises a substitution reaction and the additive comprises a base.

(39) A method of manufacturing an electronic device according to claim 38, characterized in that the functional groups comprise at least one group selected from the group consisting of -NH₂, -X (where X represents a halogen atom), -SH, -OH, -OSO₂CH₃, and -OSO₂(C₆H₄)CH₃.

(40) A method of manufacturing an electronic device according to claim 38, characterized in that the base comprises at least one compound selected from the group consisting of sodium hydroxide, potassium hydroxide, pyridine, and sodium ethoxide.

(41) A method of manufacturing an electronic device according to claim 32, characterized in that the reaction comprises an addition reaction.

(42) A method of manufacturing an electronic device according to claim 41, characterized in that the functional groups comprise -OH and/or -NCO.

(43) A method of manufacturing an electronic device according to claim 32, characterized in that the reaction comprises an oxidation reaction.

(44) A method of manufacturing an electronic device according to claim 43, characterized in that the functional groups comprise -SH.

(45) A method of manufacturing an electronic device according to claim 43, characterized in that the solution contains an oxidation reaction accelerator.

(46) A method of manufacturing an electronic device according to claim 45, characterized in that the oxidation reaction accelerator comprises iodine.

(47) A method of manufacturing an electronic device according to claim 20, characterized in that the solution further contains a solvent.

(48) A method of manufacturing an electronic device according to claim 24, characterized in that the cross-linking agent serves also as a solvent.

(49) A method of manufacturing an electronic device according to any one of claims 20 to 48, characterized by comprising a patterning step of patterning the carbon nanotube structure layer into a shape corresponding to the transporting layer.

(50) A method of manufacturing an electronic device according to claim 49, characterized in that the patterning step comprises a step involving: subjecting a carbon nanotube structure layer in a region having a pattern other than a pattern corresponding to the transporting layer on a surface of the base body to dry etching to remove the carbon nanotube structure layer in the region; and

patterning the carbon nanotube structure layer into the pattern corresponding to the transporting layer.

(51) A method of manufacturing an electronic device according to claim 49, characterized in that the patterning step comprises:

a resist layer forming step of forming a resist layer on the carbon nanotube structure layer in the region having the pattern corresponding to the transporting layer on the surface of the base body; and

a removing step of removing a carbon nanotube structure layer exposed in a region other than the region by subjecting a surface of the base body on which the carbon nanotube structure layer and the resist layer are laminated to dry etching.

(52) A method of manufacturing an electronic device according to claim 51, characterized in that, in the removing step, the surface of the base body on which the carbon nanotube structure layer and the resist layer are laminated is irradiated with a radical of an oxygen molecule.

(53) A method of manufacturing an electronic device according to claim 52, characterized in that an oxygen radical is generated by irradiating an oxygen molecule with ultraviolet light, the oxygen radical being used as the radical with which the surface of the

base body on which the carbon nanotube structure layer and the resist layer are laminated is irradiated.

(54) A method of manufacturing an electronic device according to claim 51, characterized in that the patterning step further includes, subsequent to the removing step, a resist layer peeling-off step of peeling off the resist layer formed in the resist layer forming step.

(55) A method of manufacturing an electronic device according to claim 54, characterized in that the resist layer comprises a resin layer.

(56) A method of manufacturing an electronic device according to claim 50, characterized in that the patterning step comprises a step involving: selectively irradiating the carbon nanotube structure layer in the region having a pattern other than the pattern corresponding to the transporting layer on the surface of the base body with an ion of a gas molecule in a form of an ion beam to remove the carbon nanotube structure layer in the region; and patterning the carbon nanotube structure layer into the pattern corresponding to the transporting layer.